Estimation of Biological Profile

1 Scope

This document describes guidelines for estimating the biological profile (including sex, age, ancestry, stature, or other biological features) of human skeletal material by Anthropology Examiners within the Trace Evidence Unit (TEU).

2 Equipment/Materials/Reagents

- Sliding calipers capable of measuring items up to 200mm within +/- 0.5mm (Mitutoyo Digimatic Absolute Digital Calipers 500-172-20 CD-8”CX or equivalent)
- Spreading calipers (digital or analog) capable of measuring items up to 300mm within +/- 0.5mm (Paleo-Tech Digital Linear Spreading Calipers with Mitutoyo Digimatic Absolute Digital Scale 572-213-10 or equivalent)
- 3-dimensional digitizer (MicroScribe G2 LX or equivalent)
- Personal protective equipment (e.g., lab coat, gloves, eye protection,)
- FORDISC 3.0 or equivalent
- Osteometric board (Paleo-Tech Field Osteometric Board or equivalent)
- Mandibulometer (Paleo-Tech Mandibulometer or equivalent)
- Radiography unit (NorthStar X-5000 X-radiography unit or Kubtec radiography unit or equivalent)
- Tape measure
- Human skeletal reference casts (e.g., complete skeletal reference case, age determination casts)

3 Standards and Controls

Not applicable.

4 Sampling

Not applicable.

5 Procedure

The Forensic Anthropological Examinations procedure will be followed. Depending on the completeness and condition of the skeletal remains as well as the nature of the case and

examination request, the following biological parameters may be estimated using the procedures described. In some cases, one of the following techniques may be sufficient, while in other cases, multiple techniques may be required to support the conclusions.

Skeletal material will be compared to information or data from published literature and/or skeletal reference material. Any referenced literature will be cited in the case notes. Appropriate reference literature includes bone-, age-, sex-, and ancestry-specific studies appearing in peer-reviewed journals or textbooks. Skeletal reference material includes bones, bone replicas, and bone casts produced or used for the purpose of skeletal examination and comparison.

5.1 Procedures for Sex Estimation

Sex estimation is performed by non-metric and/or metric procedures that examine sexually dimorphic characteristics of the skeleton. If available, bones that are known to exhibit the greatest sexual dimorphism (e.g., pelvis, long bones, skull) will be examined, though other bones may also be used. Selection and application of sex estimation methods depend on the skeletal elements available for examination, their condition, and the general age of the individual (e.g., adult versus subadult). Generally, the estimation model with the highest correlation and the lowest standard error will be selected.

5.1.1 Morphoscopic (Non-Metric) Methods

Skeletal differences in morphological traits vary between the sexes by shape, features, and relative size. Methods based on the pelvis are preferred. Whichever methods are applied, bone-specific reference literature and/or casts, such as pubic sex determination casts will be used when available.

5.1.2 Metric Methods

Measurements used in sex estimation generally involve limb bone size and articular surface size. Metric techniques require bone-specific literature and/or software such as FORDISC. Multiple measurements and multivariate techniques will be used when possible. For metric procedures, measurements will be taken following methods described in appropriate reference literature, depending on the metric technique used. Reference material will be used according to the method described within and cited in the case notes.

5.1.3 Subadult Sex Estimation

It is generally unadvisable to assess sex for fetal, infant, or child remains under ~12 years of age because valid sex estimation techniques are unavailable. In some instances, however, sex estimation of older adolescents may be possible.

5.2 Procedures for Age Estimation

Age estimation is based on evaluation of developmental or degenerative skeletal changes. The technique(s) used will be determined by the type, condition, and amount of remains present. Depending on the skeletal material available for analysis, the estimation model with the highest correlation and the lowest standard error will be selected.

In most cases, age estimation will be performed by visual examination and documentation of developmental or degenerative status. These techniques may require bone-specific reference literature and casts (e.g., pubic age estimation casts and rib age estimation casts). To assess the status of material that cannot be seen visually (e.g., unerupted teeth), radiologic examination may be performed using digital radiology following the Chemistry Unit, Metallurgy Digital Radiography procedure. Reference material will be used according to the method described within and cited in the case notes.

5.2.1 Age Estimation for Subadults

If teeth are present, they will be assessed for their stage of mineralization and/or eruption. This will typically require the use of radiology, but when possible may also involve direct visual examination. Dental development is more highly correlated with chronological age than bone development. Osseous development including appearance of ossification centers, long bone diaphyseal lengths, and epiphyseal union will also be used when available.

5.2.2 Age Estimation for Adults

Age estimation in adults generally involves assessment of degenerative and other skeletal changes. Certain methods are more reliable for particular periods of adult life. Valid methods include assessment of pubic symphyseal morphology, sternal rib ends, histological bone remodeling, as well as more general indicators of senility (e.g., osteoporosis, osteoarthritis, other age-related skeletal disease).

5.3 Procedures for Ancestry Estimation

Ancestry estimation is conducted by analyzing geographically-varying cranial non-metric and/or cranial and post-cranial metric characteristics commonly associated with individuals from particular geographic regions. Given the limited accuracy of the techniques available, results are usually considered suggestive rather than definitive. Depending on the skeletal element(s) available for analysis, the estimation model with the highest correlation and the lowest standard error will be selected.

5.3.1 Morphoscopic (Non-Metric) Methods

Morphoscopic techniques involve assessment of various traits and trait complexes that may suggest ancestry, requiring bone-specific reference literature.

5.3.2 Metric Methods

Metric techniques require bone-specific reference literature and FORDISC, which is considered the primary tool for metric estimation of ancestry. For metric procedures, measurements will either be taken using calipers, an osteometric board, a mandibulometer, and a tape measure according to appropriate reference literature, or using a 3D digitizer. Reference material will be used according to the method described within and cited in the case notes.

5.4 Procedures for Stature Estimation

Stature estimation provides the most probable stature of an unknown individual by performing calculations based on bone dimensions. Stature may be estimated by anatomical or regression methods as appropriate. Most stature estimation models use maximum length measurements of long bones. Depending on the skeletal element(s) available for analysis, the estimation model with the highest correlation and the lowest standard error will be used. Estimation models employed will be derived from an appropriate reference population, where available. Reference material will be used according to the method described within and cited in the case notes.

5.4.1 Anatomical Method

All bones constituting the components of stature will be measured (cranial height, lengths of vertebrae bodies and first sacral segment, femoral and tibial lengths, and tarsal heights), measurements will be summed, and corrections applied for missing soft tissue. Alternatively, the sum of the skeletal elements may be employed in a regression formula. Measurements and calculations applied will follow the relevant published method.

5.4.2 Regression Method

Complete limb bone lengths will be measured and inserted into regression formulae appropriate by time period, sex, and ancestry. Univariate or multivariate formulae may be used.

Methods based on fragmentary limb bones or non-limb bones may be used but are generally lower in precision and accuracy than those based on complete limb bones.

5.5 Other Biological Features

Other biological features of the skeleton that may further narrow the potential match pool may also be documented. Such features may include skeletal anomalies and pathologies. Anomalies include variants of the skeleton that are usually congenital or epigenetic in origin. Pathological conditions are changes in normal anatomy due to a disease process. The analysis of skeletal anomalies and pathologies may require visual, radiological, microscopic, or histological examination. Anomalies and pathologies can be identified by comparison to descriptions or exemplars from medical or anthropological sources.

5.5 Records

5.5.1 Case Notes

The case notes will include the resulting calculations and any significant observations leading to the estimation of sex, age, ancestry, or stature. Notes will include the method(s) used as applicable, the estimate, the standard used, the prediction interval, the phase or category observed, the standard error/standard deviation, and models, exemplars or reference literature used. Supporting records (e.g., FORDISC printouts) and raw data will also be included with the case notes. Reasons for not providing a requested estimate will be recorded (e.g., appropriate bone not present).

5.5.2 Reports

The FBI *Laboratory Report* (7-1, 7-1 LIMS) will include at least the estimation(s), and some indication of the basis and strength of that conclusion. Where possible, the accuracy of the estimate based on the method used will be given.

5.5.2.1 *Laboratory Reports* on the estimation of sex will be reported as "male," "female," "probable male," "probable female," or "undetermined." Degree of certainty can be expressed numerically or qualitatively. For example: "*Qualitative assessment of the pelvis indicates probable male sex.*" OR "*Quantitative assessment of the cranium indicates female sex, with a posterior probability of X*." OR "*Based on the available skeletal information, sex is undetermined.*"

5.5.2.2 *Laboratory Reports* on the estimation of age will include an age interval. For example: "*The estimated age of the individual is approximately 35-45 years.*" OR "*The estimated age of the individual is 55 years or older.*"

5.5.2.3 *Laboratory Reports* on the estimation of ancestry will include a conclusion of whether the assessment suggests "European", "African", or "Asian" ancestry, some admixture of two or more groups, or other ancestral group as indicated by the method used. If FORDISC was used, the typicality and/or posterior probabilities may be reported. For example: "*Quantitative assessment of the cranium using suggests "White" (European) ancestry with a posterior probability of 75%*, when compared to the following groups…"

5.5.2.4 *Laboratory Reports* on the estimation of stature will include the point estimate and the prediction interval. For example: "*The estimated stature of the individual is 5'5" with a 95% confidence interval of 5'3"-5'7."*

5.5.2.5 If no bones appropriate for estimating a particular parameter are present, or the condition of the bones does not permit a reliable estimate, the *Laboratory Report* will state this. For example: "*Stature could not be estimated from the available skeletal material."*

6 Calculations

Calculations carried out as part of a biological profile will be performed according to appropriate reference data.

Calculations may be carried out in accordance with the prescribed method in the reference literature, or through the use of FORDISC. The source(s) of the formula(e) and calculations used will be recorded in the case notes.

7 Measurement Uncertainty

7.1 The measurement uncertainty with calipers is approximately ± 0.02 mm or better, depending on the calipers used. Refer to instrument manuals for uncertainty for a particular caliper. This degree of uncertainty of measurement does not significantly affect anthropological conclusions and is not detrimental to the results of anthropological examinations.

7.2 The measurement uncertainty with an osteometric board is approximately ± 0.5 mm. This degree of uncertainty of measurement does not significantly affect anthropological conclusions and is not detrimental to the results of anthropological examinations.

7.3 The measurement uncertainty with the MicroScribe digitizer is less than 0.3 mm. This degree of uncertainty of measurement does not significantly affect anthropological conclusions and is not detrimental to the results of anthropological examinations.

8 Limitations

The conclusions that can be reached from anthropological examinations for estimating the biological profile of skeletal remains are dependent on the condition and completeness of the remains. Results based on fragmentary or poorly preserved material may be inconclusive.

From studies of known individuals, suites of traits as well as metric relationships are understood to characterize certain groups; however, due to variation within the human species due to both genetic and external factors (such as diet and lifestyle), no particular feature or measurement is considered diagnostic of membership in any one particular group.

Due to differences in ancestral reporting standards, possible matches with individuals of ancestries other than those reported should not be excluded without further investigation.

9 Safety

9.1 While working with physical evidence, Laboratory personnel will wear at least the minimum appropriate protective attire (e.g., laboratory coat, safety glasses, protective gloves).

9.2 Universal precautions will be followed.

9.3 Exposure to biological and radiological hazards may be associated with the examination techniques performed. Safety procedures related to specific instruments or equipment (e.g., wafering saws, radiology units) will be followed. Refer to the FBI Laboratory Safety Manual for guidance.

10 References

- Ousley SD and Jantz RL. (2005) FORDISC 3.0: Personal Computer Forensic Discriminant Functions. The University of Tennessee, Knoxville, Department of Anthropology
- Forensic Anthropological Examinations, Trace Evidence Procedures Manual (current version)
- ANSI/ASB Standard 090. Standard for Sex Estimation in Forensic Anthropology (current version)
- Scientific Working Group for Forensic Anthropology guidelines for Age Estimation (current version)
- ANSI/ASB Standard 045. Standard for Stature Estimation in Forensic Anthropology (current version)
- Scientific Working Group for Forensic Anthropology guidelines for Ancestry Estimation (current version)
- ANSI/ASB Standard 134. Standard for Analyzing Pathological Conditions and Anomalies in Forensic Anthropology (current version)
- Digital Radiography, Chemistry Unit, Metallurgy (current version)
- FBI Laboratory Safety Manual (current version)

Rev. #	Issue Date	History
2	02/10/2020	Updated wording in Scope and Section 5.2. Changed 'forensic anthropologist' to 'Anthropology Examiner' in Scope. Removed 'Sample Selection' from Section 4 title. Added Section 5.5. Updated reference to Chemistry procedure. Changed Fordisc to FORDISC throughout for consistency.
3	08/22/2021	Replaced SWGANTH documents with OSAC standards in References. Language (including Reporting examples) revised to reflect language in OSAC documents.

Approval

Redact - Signatures on File

Trace Evidence Unit Chief: Date: 07/30/2021

Anthropology Technical Leader: Date: 07/30/2021